Int. J. Vitam. Nutr. Res., 69 (6), 1999, 419–427

Variability in Selected Indexes of Overall Diet Quality

Ashima K. Kant[1] and Barry I. Graubard[2]

[1]Queens College of the City University of New York, Flushing, NY 11367, USA
[2]National Cancer Institute, National Institutes of Health, Bethesda, MD 20892, USA

Received for publication: May 31, 1999

Abstract: We examined the intra- and interindividual variability in selected measures of overall diet quality in relation to socio-demographic, lifestyle, and health-related characteristics. Three days of dietary data from the Continuing Survey of Food Intakes by Individuals (CSFII), 1989–91 (7841 respondents, 3337 men and 4504 women, aged ≥ 19 years), were examined. Measures of overall diet quality were: 1. the Dietary Diversity Score (DDS), a measure of variety among the major food groups; 2. the Overall Variety Score (OVS), examined the number of nutrient-dense foods reported; and 3. the Nutrient Adequacy Score (NAS100), evaluated the number of nutrients consumed at least at the level of the RDA from a total of 11. The ratio of intra- to interindividual variance for DDS, OVS, and NAS100 was 1.66, 1.09, and 1.21, respectively, indicating higher intraindividual variability relative to interindividual variability. For each of the three scores, gender, income, education, and smoking were associated with greater intraindividual variability; however, age, and special diet status were associated with lower variability. Thus, the reliability of a given dietary assessment protocol for evaluating "usual" diet quality is likely to vary by the socio-demographic and lifestyle characteristics of the study population.

Key words: Overall diet quality, dietary diversity, variability, intraindividual variation, interindividual variation, CSFII, components of variance, dietary measurement, nutrition survey, diet quality indexes

Introduction

Assessment of overall diet quality has been the subject of several recent investigations [1–10]. The interest in examining overall diet quality reflects increasing recognition of the limitations of single nutrients or foods/food groups for characterizing food consumption patterns given the complex nature of diets consumed by free-living individuals, and multicollinearity of dietary variables. Several studies that examined the relation of measures of overall diet quality with a variety of health outcomes including mortality from all causes, heart disease, and cancer have also appeared recently [11–17].

These developments underscore the need to learn more about the nature of measures of overall diet quality. Little is known about the extent of intra- and interindividual variability in global measures of dietary quality. In the past attention has been paid to obtaining estimates of intra- and interindividual variability for nutrients [18–25], and to a limited extent for food groups [24, 26, 27].

The information on the extent of variability in measures of overall diet quality will be useful in determining the accuracy of estimates of "usual" level of overall diet quality given the number of dietary measurements available. Further, for large samples, such estimates may also permit a statistical correction of attenuation of simple measures of association due to large intraindividual variability [28]. The information on components of variance and their ratio is also useful for design of studies interested in examining overall diet quality [29]. For example, knowledge of estimated intraindividual variability facilitates sample size calculations to enable detection of significant differences. The estimated ratio of variance components can be used for determination of repeated dietary measurements needed to obtain estimates of usual level of diet quality.

The purpose of this study was to examine the intra- and interindividual variability in three different measures of overall diet quality based on individual foods, food groups, and nutrient intake. Because little is known about the sociodemographic and lifestyle correlates of variability in measures of overall diet quality, these issues were also examined.

Methods

We used data from the Continuing Survey of Food Intake by Individuals (CSFII), Series II, 1989–1991, conducted by the United States Department of Agriculture. The CSFII (1989–91) contains a multi-stage, national probability sample of US households and includes a basic sample containing all-income households and a low-income sample [30]. Dietary information for three consecutive days was obtained from all members of sampled households, and included one interviewer administered 24-hour dietary recall and 2-day food records.

Analytic sample: For the purpose of analyses reported here, all respondents aged ≥ 19 years (n = 8340), with three complete days of dietary information were eligible for inclusion in the analytic sample. From this eligible sample, we excluded women who were pregnant (n = 119), lactating (n = 70), or subjects answering yes to not eating enough food on dietary assessment days due to illness, lack of money or fasting (n = 310). The final analytic sample included 7841 respondents (3337 men and 4504 women).

Measures of overall diet quality: Three measures of overall diet quality were examined for variability: 1. Dietary Diversity Score (DDS); 2. Overall Variety Score (OVS); and 3. Nutrient Adequacy Score (NAS100).

The indexes chosen represent three different approaches to evaluation of overall diet quality. The DDS is a food group based score and has been related to health outcome in the published literature [4, 11, 12]. The OVS is driven by consumption of individual food items and is one of the most popular indexes of dietary variety in the published literature [1]. The NAS100, is a nutrient based index, and was chosen because a large body of published literature on overall diet quality is derived from variations of this index [1].

The DDS as reported previously by us [7], is based on variety among the five major food groups (fruit, vegetable, grain, dairy, and meat). This score increases by one as a major food group is encountered in each dietary measurement; the maximum possible score is 5. The overall variety score (OVS) is a sum of unique foods reported on the day of dietary measurement from among the five major food groups. Food mixtures containing foods from several food groups could contribute as many points to the OVS as the food groups comprising the mixed dish. The nutrient adequacy score (NAS100) is an assessment of the number of nutrients consumed at least at the level of 100% of the RDA from a total of 11.

To compute the OVS or the DDS for each respondent, foods reportedly consumed at least once by respondents in the analytic sample (total of 4,689 foods) were first grouped into the nutrient-dense or the nutrient-poor, energy-dense categories. The nutrient-dense category contained foods from the five major food groups – dairy, meat, grain, fruit, and vegetable. The methods used for categorizing foods have been described previously [7]. Foods such as butter, oils, sweeteners, carbonated and alcoholic beverages, fruit drinks, jams and jellies, and cakes/pies/cookies were excluded from the major food groups and grouped into the energy-dense, nutrient-poor category. Mixed dishes containing foods from more than one group, e.g., stews or lasagna, were placed in each food group comprising the dish. Thus, e.g., meat lasagna was placed in dairy, meat, grain, and vegetable groups.

Statistical analysis: All statistical analyses were performed using SAS [31]. Statistical software recommended for analysis of complex survey data (SUDDAN) was used to obtain standard errors of estimates [32]. Procedures for estimation of variance components from complex survey data are not yet available in the SUDDAN package. Therefore, sampling and complex survey design adjusted estimates of inter and intra-individual variability (variance components) were obtained using previously described methods [33]. The ratios of intraindividual to interindividual variance components were also computed for each measure of dietary quality. This ratio serves as a summary indicator of the extent of intraindividual variability relative to variability among individuals. A ratio of more than one suggests that intraindividual variability is greater than the interindividual variability [29]. Standard error of the ratio of the variance components was obtained using the jackknife method as previously described [33].

Using the estimated variance components we also computed intraclass correlation coefficients to determine what proportion of the total variability is accounted for by intraindividual variance [34]. A high intraclass correlation suggests that dietary intakes on different days by an individual are highly correlated and that most of the variability is contributed by differences among individuals.

Results

Descriptive statistics on the three scores are presented in Table I. The mean DDS (number of food groups consumed from the 5 major food groups) 3-day average score was 4.0 ± 0.02. Nearly 46% of respondents scored less than 5 on the DDS on all three days, with only 11% scoring 5 on all three days (data not shown). The 3-day average mean ± SE OVS (number of unique nutrient-dense foods), NAS100 (number of nutrients consumed at least at the RDA level from a total of 11) were 7.8 ± 0.07 and 5.7 ± 0.08, respectively.

Table II presents the association of the 3-day average of the three scores with intake of energy and selected nutrients. All three scores correlated positively with energy and nutrient intake ($p < 0.05$), but were inversely related (DDS, OVS) or unrelated (NAS100) with fat intake.

Tables III–V present the intra- and interindividual variance, and the ratio ± SE of the two variances, for the three overall diet quality scores by selected socio-demographic, life-style, and other health-related variables. With minor exceptions, the variance ratios for the three scores stratified by socio-demographic, lifestyle, health-related factors were greater than one. Women had higher variance ratios relative to men for each of the three scores. No consistent trends in the relation of variance ratios with ethnicity across the three scores were noted. For each score, increasing age was associated with lower variance ratios; however, increasing education, income, and employment were associated with higher ratios.

Never smokers had the smallest variance ratios relative to former or current smokers for each of the three scores. No trends in the relation of leisure-time physical activity, self-described health status, or body weight status with variance ratios were evident for any of the scores. Regular use of vitamin/mineral supplements or being on a special diet was associated with smaller variance ratios for each of the three scores.

The intraclass correlation coefficients for the three scores were generally low (< 0.5), suggesting that more of the variability in estimates of these scores was due to the intraindividual variability.

Table II: Correlation (Pearson's r) of the 3-day average overall diet quality scores with energy and nutrient intake

Nutrient	DDS	OVS	NAS100
DDS	1.00	0.72	0.52
OVS	0.72	1.00	0.66
Energy (kcal)	0.25	0.48	0.67
Fat (% energy)	–0.11	–0.03	–0.00
Vitamin C	0.44	0.49	0.51
Vitamin B-6	0.41	0.53	0.75
Folate	0.41	0.53	0.71
Vitamin A (RE)	0.27	0.35	0.46
Vitamin E	0.23	0.37	0.55
Calcium	0.37	0.44	0.64
Iron	0.29	0.45	0.69
Fiber	0.39	0.59	0.65

DDS = variety among food groups. Maximum score = 5; one point each is contributed by the food groups – dairy, meat, grain, fruit, and vegetable.
OVS = number of unique nutrient-dense foods consumed per day.
NAS100 = number of nutrients for which at least 100% of the RDA was reported. Maximum score = 11 (nutrients include: protein, vitamin A, vitamin E, vitamin C, vitamin B-12, vitamin B-6, folate, calcium, potassium, zinc, and iron).

Table I: Descriptive statistics on three measures of overall diet quality

	Day 1	Day 2	Day 3	3-day average
Dietary Diversity Score (DDS)				
Mean ± SEM	4.03 ± 0.02	3.97 ± 0.02	3.99 ± 0.02	4.00 ± 0.02
95% CI[1]	3.99 – 4.07	3.93 – 4.01	3.95 – 4.03	3.96 – 4.04
Overall Variety Score (OVS)				
Mean ± SEM	7.92 ± 0.07	7.73 ± 0.07	7.75 ± 0.08	7.80 ± 0.07
95% CI	7.78 – 8.06	7.59 – 7.87	7.59 – 7.91	7.66 – 7.94
Nutrient Adequacy Score (NAS100)				
Mean ± SEM	5.41 ± 0.08	5.16 ± 0.07	5.17 ± 0.07	5.69 ± 0.08
95% CI	5.25 – 5.57	5.02 – 5.29	5.03 – 5.31	5.53 – 5.84

[1] 95% CI = 95% confidence interval.
DDS = Measures variety among food groups. Maximum scores = 5; one point each is contributed by the food groups – dairy, meat, grain, fruit, and vegetable.
OVS = number of unique nutrient-dense foods consumed per day.
NAS100 = number of nutrients for which at least 100% of the RDA was reported. Maximum score = 11 (nutrients include: protein, vitamin A, vitamin E, vitamin C, vitamin B-12, vitamin B-6, folate, calcium, potassium, zinc, and iron). Percent RDA consumed over three days was averaged before computation of the three-day average NAS100.

Table III: Intra- and inter-individual variance, variance ratio ± SE, and intraclass correlation coefficient ± SE of the dietary diversity score (DDS); three days of dietary data for 7, 841 adults, CSFII, 1989–1991

	n	Intra (Within) Variance	Inter (Between) Variance	Intra/inter Within/Between Ratio ± SE	Intraclass Corr. ± SE
All	7841	0.47	0.28	1.66 ± 0.10	0.38 ± 0.01
Socio-demographic variables					
Gender					
Men	3337	0.43	0.27	1.59 ± 0.12	0.38 ± 0.02
Women	4504	0.51	0.30	1.72 ± 0.13	0.37 ± 0.02
Ethnicity					
White	6078	0.46	0.27	1.69 ± 0.12	0.37 ± 0.02
Black	906	0.57	0.30	1.87 ± 0.29	0.35 ± 0.03
Hispanic	646	0.48	0.25	1.94 ± 0.34	0.34 ± 0.04
Other	211	0.59	0.39	1.52 ± 0.38	0.40 ± 0.06
Agegroup					
19–34 years	2495	0.51	0.24	2.12 ± 0.20	0.32 ± 0.02
35–50 years	2194	0.50	0.28	1.83 ± 0.20	0.35 ± 0.02
51–64 years	1374	0.43	0.26	1.63 ± 0.18	0.38 ± 0.02
≥ 65 years	1778	0.39	0.29	1.31 ± 0.13	0.43 ± 0.02
Education					
< 12 years	2384	0.47	0.32	1.46 ± 0.13	0.41 ± 0.02
12 years	2809	0.48	0.29	1.65 ± 0.16	0.38 ± 0.02
> 12 years	2556	0.47	0.25	1.90 ± 0.19	0.34 ± 0.02
Income as percent of poverty threshold					
0–130	3008	0.47	0.36	1.32 ± 0.10	0.43 ± 0.02
131–350	2852	0.50	0.28	1.77 ± 0.15	0.36 ± 0.02
≥ 351	1981	0.45	0.25	1.83 ± 0.17	0.35 ± 0.02
Employment Status					
Full-time	3016	0.47	0.23	2.02 ± 0.14	0.33 ± 0.01
Part-time	936	0.50	0.32	1.55 ± 0.23	0.39 ± 0.03
Not employed	3659	0.45	0.34	1.34 ± 0.13	0.43 ± 0.02
Lifestyle variables					
Smoking Status					
Never	4115	0.46	0.27	1.68 ± 0.14	0.37 ± 0.02
Former	1587	0.45	0.23	1.91 ± 0.19	0.34 ± 0.02
Current	2094	0.53	0.28	1.89 ± 0.19	0.34 ± 0.02
Level of leisure time physical activity					
Heavy	857	0.47	0.25	1.87 ± 0.21	0.35 ± 0.02
Moderate	3337	0.47	0.26	1.77 ± 0.16	0.36 ± 0.02
Light	3483	0.48	0.32	1.50 ± 0.12	0.40 ± 0.02
Bedridden	106	0.43	0.29	1.51 ± 0.67	0.40 ± 0.10
Other health-related variables					
Self-described health status					
Excellent	1412	0.48	0.24	1.94 ± 0.11	0.33 ± 0.02
Very good	2326	0.48	0.26	1.85 ± 0.11	0.35 ± 0.02
Good	2635	0.47	0.30	1.56 ± 0.10	0.39 ± 0.02
Fair	1052	0.45	0.36	1.24 ± 0.11	0.44 ± 0.04
Poor	346	0.50	0.38	1.33 ± 0.15	0.43 ± 0.05
Weight staatus					
Normal	5471	0.46	0.28	1.65 ± 0.10	0.38 ± 0.01
Overweight[1]	2251	0.50	0.30	1.68 ± 0.19	0.37 ± 0.02
How often take any vitamin/mineral supplements?					
Every day	2070	0.43	0.28	1.53 ± 0.08	0.39 ± 0.03
Every so often	795	0.54	0.23	2.39 ± 0.21	0.29 ± 0.03
Not at all	4915	0.48	0.28	1.69 ± 0.08	0.37 ± 0.02
Special diet status					
Yes	1213	0.44	0.35	1.27 ± 0.16	0.44 ± 0.03
No	6572	0.48	0.27	1.76 ± 0.11	0.36 ± 0.01
Don't know	56	0.64	0.24	2.63 ± 1.95	0.28 ± 0.12

DDS = variety among food groups. Maximum score = 5; one point each is contributed by the food groups – dairy, meat, grain, fruit, and vegetable. [1] Overweight was defined as a Body Mass Index (BMI) of ≥ 27.8 and ≥ 27.3 for men and women, respectively.

Table IV: Intra- and inter-individual variance, and variance ratio ± SE, intraclass correlation coefficient ± SE, of the nutrient adequacy score (NAS100): three days of dietary data for 7, 841 adults, CSFII, 1989–1991

	n	Intra (Within) Variance	Inter (Between) Variance	Intra/inter Within/Between Ratio ± SE	Intraclass Corr. ± SE
All	7841	5.46	4.49	1.21 ± 0.06	0.45 ± 0.01
Socio-demographic variables					
Gender					
Male	3337	5.41	4.09	1.32 ± 0.09	0.43 ± 0.02
Female	4504	5.50	4.02	1.36 ± 0.10	0.42 ± 0.02
Ethnicity					
White	6078	5.54	4.35	1.27 ± 0.07	0.44 ± 0.01
Black	906	5.09	4.89	1.03 ± 0.15	0.49 ± 0.03
Hispanic	646	5.05	4.12	1.22 ± 0.28	0.44 ± 0.05
Other	211	5.31	5.63	0.94 ± 0.25	0.51 ± 0.07
Agegroup					
19–34 years	2495	5.95	4.39	1.35 ± 0.12	0.42 ± 0.02
35–50 years	2194	5.55	4.41	1.25 ± 0.12	0.44 ± 0.02
51–64 years	1374	5.51	4.26	1.29 ± 0.15	0.44 ± 0.03
≥ 65 years	1778	4.29	4.93	0.87 ± 0.07	0.53 ± 0.02
Education					
< 12 years	2384	5.07	4.51	1.12 ± 0.10	0.47 ± 0.02
12 years	2809	5.40	4.33	1.24 ± 0.10	0.44 ± 0.20
> 12 years	2556	5.64	4.36	1.29 ± 0.11	0.43 ± 0.02
Income as percent of poverty threshold					
0–130	3008	5.00	4.54	1.09 ± 0.08	0.48 ± 0.02
131–350	2852	5.41	4.66	1.16 ± 0.10	0.46 ± 0.02
≥ 351	1981	5.64	4.03	1.39 ± 0.11	0.42 ± 0.02
Employment Status					
Full-time	3016	5.69	4.12	1.37 ± 0.10	0.42 ± 0.02
Part-time	936	5.42	4.80	1.12 ± 0.14	0.47 ± 0.03
Not employed	3659	5.10	4.91	1.03 ± 0.08	0.49 ± 0.02
Lifestyle variables					
Smoking Status					
Never	4115	5.36	4.87	1.10 ± 0.08	0.48 ± 0.02
Former	1587	5.44	3.73	1.45 ± 0.15	0.41 ± 0.02
Current	2094	5.67	4.05	1.40 ± 0.13	0.42 ± 0.02
Level of leisure time physical activity					
Heavy	857	5.44	4.72	1.15 ± 0.15	0.46 ± 0.03
Moderate	3337	5.62	4.15	1.35 ± 0.09	0.43 ± 0.02
Light	3483	5.30	4.67	1.13 ± 0.08	0.47 ± 0.02
Bedridden	106	4.80	2.78	1.72 ± 0.61	0.37 ± 0.08
Other health-related variables					
Self-described health status					
Excellent	1412	5.40	4.93	1.09 ± 0.10	0.48 ± 0.02
Very good	2326	5.55	4.11	1.35 ± 0.13	0.42 ± 0.02
Good	2635	5.60	4.40	1.27 ± 0.10	0.44 ± 0.02
Fair	1052	5.16	4.79	1.08 ± 0.13	0.48 ± 0.03
Poor	346	4.67	3.74	1.25 ± 0.20	0.44 ± 0.04
Weight status					
Normal	5471	5.42	4.43	1.22 ± 0.07	0.45 ± 0.01
Overweight[1]	2251	5.52	4.71	1.16 ± 0.12	0.46 ± 0.02
Special diet status					
Yes	1213	5.09	4.69	1.08 ± 0.11	0.48 ± 0.02
No	6572	5.53	4.44	1.25 ± 0.07	0.44 ± 0.01
How often take vitamin/mineral supplements?					
Every day	2070	5.38	4.51	1.19 ± 0.09	0.46 ± 0.02
Every so often	795	5.65	3.85	1.47 ± 0.18	0.40 ± 0.03
Not at all	4915	5.48	4.50	1.22 ± 0.08	0.45 ± 0.02

NAS100 = number of nutrients for which at least 100% of the RDA was reported. Maximum score = 11 (nutrients include: protein, vitamin A, vitamin E, vitamin C, vitamin B-12, vitamin B-6, folate, calcium, potassium, zinc, and iron).
[1] Overweight was defined as a Body Mass Index (BMI) of ≥ 27.8 and ≥ 27.3 for men and women, respectively.

Table V: Intra- and inter-individual variance, and variance ratio ± SE, intraclass correlation coefficient ± SE, of the overall variety score (OVS); three days of dietary data for 7,841 adults, CSFII, 1989–1991

	n	Intra (Within) Variance	Inter (Between) Variance	Intra/inter Within/Between Ratio ± SE	Intraclass Corr. ± SE
All	7841	4.29	3.93	1.09 ± 0.06	0.48 ± 0.01
Socio-demographic variables					
Gender					
Male	3337	4.66	4.28	1.09 ± 0.09	0.48 ± 0.02
Female	4504	3.95	3.39	1.16 ± 0.07	0.46 ± 0.01
Ethnicity					
White	6078	4.30	3.85	1.12 ± 0.07	0.47 ± 0.01
Black	906	3.43	3.72	0.92 ± 0.20	0.52 ± 0.05
Hispanic	646	4.69	3.48	1.35 ± 0.26	0.43 ± 0.05
Other	211	6.67	3.87	1.72 ± 0.61	0.37 ± 0.08
Agegroup					
19–34 years	2495	4.97	3.24	1.53 ± 0.16	0.39 ± 0.02
35–50 years	2194	4.29	3.79	1.13 ± 0.12	0.47 ± 0.03
51–64 years	1374	4.18	4.16	1.00 ± 0.11	0.50 ± 0.03
≥ 65 years	1778	3.12	4.60	0.68 ± 0.05	0.60 ± 0.02
Education					
< 12 years	2384	3.51	3.15	1.11 ± 0.09	0.47 ± 0.02
12 years	2809	4.23	3.93	1.08 ± 0.10	0.48 ± 0.02
> 12 years	2556	4.69	4.03	1.16 ± 0.09	0.46 ± 0.02
Income as percent of poverty threshold					
0–130	3008	3.48	3.55	0.98 ± 0.07	0.51 ± 0.02
131–350	2852	4.17	3.65	1.14 ± 0.11	0.47 ± 0.02
≥ 351	1981	4.64	3.94	1.17 ± 0.10	0.46 ± 0.02
Employment Status					
Full-time	3016	4.62	3.73	1.24 ± 0.11	0.45 ± 0.02
Part-time	936	4.10	3.68	1.11 ± 0.15	0.47 ± 0.03
Not employed	3659	3.90	4.41	0.88 ± 0.07	0.53 ± 0.02
Lifestyle variables					
Smoking Status					
Never	4115	4.29	4.31	0.99 ± 0.07	0.50 ± 0.02
Former	1587	4.32	3.40	1.27 ± 0.15	0.44 ± 0.03
Current	2094	4.30	2.74	1.57 ± 0.13	0.39 ± 0.02
Level of leisure time physical activity					
Heavy	857	5.03	4.54	1.11 ± 0.15	0.47 ± 0.03
Moderate	3337	4.19	3.59	1.17 ± 0.08	0.46 ± 0.02
Light	3483	4.20	4.07	1.03 ± 0.08	0.49 ± 0.02
Bedridden	106	3.26	2.23	1.46 ± 0.66	0.41 ± 0.11
Other health-related variables					
Self-described health status					
Excellent	1412	4.55	4.15	1.10 ± 0.11	0.48 ± 0.02
Very good	2326	4.31	3.67	1.17 ± 0.10	0.46 ± 0.02
Good	2635	4.26	4.05	1.05 ± 0.10	0.49 ± 0.02
Fair	1052	4.14	3.87	1.07 ± 0.11	0.48 ± 0.02
Poor	346	3.27	3.29	0.99 ± 0.15	0.50 ± 0.04
Weight status					
Normal	5471	4.20	4.02	1.05 ± 0.07	0.49 ± 0.02
Overweight[1]	2251	4.50	3.68	1.22 ± 0.11	0.45 ± 0.02
How often take vitamin/mineral supplements?					
Every day	2070	4.37	4.47	0.98 ± 0.08	0.51 ± 0.02
Every so often	795	4.69	3.05	1.54 ± 0.22	0.39 ± 0.03
Not at all	4915	4.17	3.69	1.13 ± 0.08	0.47 ± 0.02
Special diet status					
Yes	1213	3.47	5.35	0.65 ± 0.08	0.61 ± 0.03
No	6572	4.43	3.66	1.21 ± 0.08	0.45 ± 0.02
Don't know	56	4.71	2.15	2.19 ± 0.91	0.31 ± 0.09

OVS = number of unique nutrient-dense foods consumed per day.
[1] Overweight was defined as a Body Mass Index (BMI) of ≥ 27.8 and ≥ 27.3 for men and women, respectively.

Discussion

To our knowledge this is the first study to provide national estimates for: 1. intra- and interindividual variability in selected measures of overall diet quality, and 2. to examine differences in variance ratios because of correlates of nutrient intake such as socio-demographic and life-style factors. Although estimates of variability of nutrients [18–25] and food groups are available [24, 26, 27], no other published estimates of variability of dietary variety or other measures of overall diet quality are available to permit a comparison with the estimates reported herein.

As shown in Tables III–V, the ratios of within subject variance (intraindividual) to between subject variance (interindividual) were greater than one, and the intraclass correlation coefficients were less than 0.5 for most subgroups examined, thus indicating that the variability within subjects was higher than the variability between subjects. We noted consistently higher ratios in women relative to men for each of the three scores (Tables III–V). Women also had higher ratios relative to men in each subgroup for the three scores examined. (Gender-specific subgroup variance component data not shown.) Others have also reported gender differences in variance ratios of several nutrients, but not always in the same direction [19, 23]. With some exceptions, subgroups with high intraindividual variance also had high interindividual variance. Among the exceptions is the agegroup ≥ 65 years, which had the lowest intraindividual variance and highest interindividual variance relative to the three younger agegroups for all three scores. For both OVS and NAS100 the variance ratios for the ≥ 65 year agegroup were less than one. The implication of the observed subgroup differences in variance ratios is that the number of replicate measurements needed to minimize the effect of intraindividual variability will vary by sub-groups comprising a population. Therefore, the extent to which a fixed number of dietary measurements yield estimates of usual intake will be different for subgroups in a population. However, the practical application of this observation may be limited to studies focusing on specific subgroups such as smokers or the elderly. Liu has argued that in large population surveys, using different number of dietary measurements for population subgroups will complicate data analysis and introduce biases [28].

We had no apriori hypotheses regarding the relation of socio-demographic or lifestyle variables with the extent of variability. Generally, the trends in socio-demographic, and lifestyle differences are in accord with intuitive reasoning. For example as noted previously, with higher income and education, there was more variability both among and within individuals, as might be expected with more knowledge and availability associated with education and income. Similarly, with increasing age, as individuals develop typical food patterns, a decrease in intraindividual but increase in interindividual variability was noted.

Previous reports suggest higher variance ratios for foods/food groups relative to nutrients [24, 26]. Of the two food/food group based measures of overall diet quality examined in our study, the lowest variance ratios were noted for the OVS (1.09), and the highest for the DDS (1.66). The variance ratios for the (OVS) were smaller than the published ratios for most nutrients [19–24] and food groups [24, 26]. Even the variance ratio for DDS (1.66) is smaller than the ratios reported for most food groups. One reason for these smaller variance ratios may be that the measures examined (DDS and OVS) do not consider the amount of food consumed beyond a minimum qualifying cutoff. One consequence of not considering the amount may be to decrease both the intra- and the interindividual variability in these scores. However, the decline in intraindividual variability may be greater than that of interindividual variability because there is evidence that portions consumed have greater intraindividual variance relative to the interindividual component [35].

Some limitations of our study must be acknowledged. The data were limited to three consecutive dietary measurements. There is evidence that dietary intake on consecutive days tends to be correlated [24], thus resulting in smaller variance ratios relative to when the intake is examined on nonconsecutive days. Furthermore, no information is available on whether dietary intake of the various socio-demographic subgroups in a population has similar degree of correlation on consecutive days.

In conclusion, the intraindividual variability was higher than the interindividual variability in all three measures of overall diet quality examined. The extent of variability appeared to be associated with socio-demographic, lifestyle, and health-related factors. Further work on understanding the extent of variability in other recently proposed global measures of healthy diet (e.g., the Healthy Eating Index of USDA) is needed.

Acknowledgement

We thank Lisa Licitra Kahle, IMS, Silver Spring, MD, for computing assistance.

References

1. Kant, A. K. (1996) Indexes of overall diet quality: A review. J. Am. Diet. Assoc. 96, 785–791.

2. Kennedy, E. T., Ohls, J., Carlson, S. and Fleming, K. (1995) The Healthy Eating Index: Design and applications. J. Am. Diet Assoc. 95, 1103–1108.
3. Patterson, R. E., Haines, P. S. and Popkin, B. M. (1994) Diet quality index: capturing a multidimensional behavior. J. Am. Diet Assoc. 94, 57–64.
4. Drewnowski, A., Henderson, S. A., Shore, A. B., Fischler, C., Preziosi, P. and Hercberg, S. (1996) Diet quality and dietary diversity in France: implications for the French paradox. J. Am. Diet Assoc. 96, 663–669.
5. Popkin, B. M., Siega-Riz, A. M. and Haines, P. S. (1996) A comparison of dietary trends among racial and socioeconomic groups in the United States. N. Engl. J. Med. 335, 716–720.
6. Kumanyika, S. (1996) Improving our diet – still a long way to go. N. Engl. J. Med. 335, 738–740.
7. Kant, A. K., Block, G., Schatzkin, A., Ziegler, R. G. and Nestle, M. (1991) Dietary diversity in the US population, NHANES II, 1976–80. J. Am. Diet Assoc. 91, 1526–1531.
8. Randall, E., Marshall, J., Graham, S. and Brasure, J. (1989) Frequency of food use data and the multidimensionality of diet. J. Am. Diet Assoc. 89, 1070–1075.
9. Kant, A. K. and Thompson, F. E. (1997) Measures of overall diet quality from a food frequency questionnaire: National Health Interview Survey, 1992. Nutr. Res. 17, 1443–1456.
10. Davenport, M., Roderick, P., Elliott, L., Victor, C. and Geissler, C. (1995) Monitoring dietary change in populations and the need for specific food targets; lessons from the North West Thames Regional Health Survey. J. Human Nutr. Diet 8, 119–128.
11. Kant, A. K., Schatzkin, A., Harris, T., Ziegler, R. G. and Block, G. (1993) Dietary diversity and subsequent mortality in the First National Health and Examination Survey Epidemiologic Follow-up Study. Am. J. Clin. Nutr. 57, 434–440.
12. Kant, A. K., Schatzkin, A. and Ziegler, R. (1995) Diet diversity and subsequent cause-specific mortality. J. Am. Coll. Nutr. 14, 233–238.
13. Fernandez, E., D'Avanzo, B., Negri, E., Franceschi, S. and La Vecchia, C. (1996) Diet diversity and the risk of colorectal cancer in Northern Italy. Cancer Epidemiology, Biomarkers and Prevention 5, 433–436.
14. La Vecchia, C., Munoz, S. E., Braga, C., Fernandez, E. and Decarli, A. (1997) Diet diversity and gastric cancer. Int. J. Cancer 72, 255–257.
15. Fransceschi, S., Favero, A., La Vecchia, C., Negri, E., Dal Maso, L., Salvini, S., Decarli, A. and Giacosa, A. (1995) Influence of food groups and food diversity on breast cancer risk in Italy. Int. J. Cancer 63, 785–789.
16. Wahlquist, M. L., Lo, C. S. and Myers, K. A. (1986) Food variety is associated with less macrovascular disease in those with Type II diabetes and their healthy controls. J. Am. Coll. Nutr. 6, 515–523.
17. Miller, W. L., Crabtree, B. F. and Evans, D. K. (1992) Exploratory study of the relationship between hypertension and diet diversity among Saba islanders. Public Health Rep. 107, 426–432.
18. Liu, K., Stamler, J., Dyer, A. et al (1978) Statistical methods to assess and minimize the role of intra-individual variability in observing the relationship between dietary lipids and serum cholesterol. J. Chron. Dis. 31, 399–418.
19. Beaton, G. H., Milner, J., Corey, P., McGuire, V., Cousins, M., Stewart, E., de Ramos, M., Hewitt, D., Grambsch, P. V., Kassim, N. and Little, J. A. (1979) Sources of variance in 24-hour recall data: implications for nutrition study design and interpretation. Am. J. Clin. Nutr. 32, 2456–2559.
20. Beaton, G. H., Milner, J., McGuire, V., Feather, T. E. and Little, J. A. (1983) Source of variance in 24-hour dietary recall data: implications for nutrition study design and interpretation. Carbohydrate sources, vitamins, and minerals. Am. J. Clin. Nutr. 37, 986–995.
21. Sempos, C. T., Johnson, N. E., Smith, E. L. and Gilligan, C. (1985) Effects of intraindividual and interindividual variation in repeated dietary records. Am. J. Epidemiol. 121, 120–130.
22. Marr, J. W. and Heady, J. A. (1986) Within- and between-person variation in dietary surveys: number of days needed to classify individuals. Human Nutr. Applied Nutrition 40a, 347–364.
23. Nelson, M., Black, A. E., Morris, J. E. and Cole, T. J. (1989) Between- and within-subject variation in nutrient intake from infancy to old age: estimating the number of days required to rank dietary intakes with desired precision. Am. J. Clin. Nutr. 50, 155–167.
24. Hartmann, A. M., Brown, C. C., Palmgren, J., Pietinen, P., Verkasalo, M., Myer, D. and Virtamo, J. (1990) Variability in nutrient and food intakes among older middle-aged men. Implications for design of epidemiologic and validation studies using food recording. Am. J. Epidemiol. 132, 999–1012.
25. Piwoz, E. G., Creed de Kanashiro, H., Lopez de Romana, G., Black, R. E. and Brown, K. H. (1994) Within- and between-individual variation in energy intakes by low-income Peruvian infants. Eur. J. Clin. Nutr. 48, 333–340.
26. Sempos, C. T., Johnson, N. E., Gilligan, C. and Smith, E. L. (1986) Estimated ratios of within-person to between-person variation in selected food groups. Nutr. Rep. International 34, 1121–1127.
27. Borrelli, R., Simonetti, M. S. and Fidanza, F. (1992) Inter- and intra-individual variability in food intake of elderly people in Perugia (Italy). Br. J. Nutr. 68, 3–10.
28. Liu, K. (1992) Statistical issues related to the design of dietary survey methodology for NHANES III. In: Dietary Methodology Workshop for the Third National Health and Nutrition Examination Survey. NCHS, Series A, No. 27, pp. 3–14.
29. Sempos, C. T., Looker, A. C., Johnson, C. L. and Woteki, C. E. (1991) The importance of within-person variability in estimating prevalence. In: Monitoring dietary intakes (McDonald, I., ed.), pp. 99–109. Springer Verlag, New York, NY.
30. US Department of Agriculture, Agriculture Research Service (1995) Food and Nutrient Intake by Individuals in the United States, 1 Day, 1989–91. Continuing Survey of Food

Intakes by Individuals, 1989–91, NFS Report Number 91–92.
31. SAS Institute Inc. SAS User's Guide. Version 6 Edition. Cary, NC: SAS Institute Inc. 1990.
32. Shah, B. V., Barnwell, B. G., Hunt, P. N. and Lavange, L. M. (1991) SUDAAN User's manual. Professional Software for Survey Data Analysis for multi-stage sample designs. Research Triangle Park, NC: Research Triangle Institute.
33. Graubard, B. I. and Korn, E. L. (1996) Modeling the sampling design in the analysis of health surveys. Statistical Methods in Med. Res. 5, 263–281.
34. Snedecor, G. W. and Cochran, W. G. (1989) Statistical Methods. 8th ed. Iowa University Press, Ames, Iowa.
35. Hunter, D. J., Sampson, L., Stampfer, M. J., Colditz, G. A., Rosner, B. and Willett, W.C. (1988) Variability in portion sizes of commonly consumed foods among a population of women in the United States. Am. J. Epidemiol. 127, 1240–1249.

Ashima K. Kant, PhD

Dept. of Family, Nutrition, and Exercise Sciences
Remsen Hall, Room 306 E
Queens College, The City University of New York
65-30 Kissena Blvd
Flushing, NY 11367, USA